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DEVELOPMENT OF A CONCEPTUAL FRAMEWORK FOR THE TEACHING OF INDUSTRIAL ARTS.

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CREATING IN SECONDARY SCHOOL STUDENTS AN AWARENESS FOR THE IMPACT OF TECHNOLOGY UPON THEIR DAILY LIVES WAS THE AIM OF THIS STUDY. A NEW ORIENTATION FOR INDUSTRIAL ARTS TEACHERS ATTEMPTED TO DEFINE A CURRICULUM AREA FOR COMPREHENSION OF THE BROAD SCOPE OF AMERICAN INDUSTRY, RATHER THAN THE USUAL FOCUS UPON ISOLATED TRADES, OCCUPATIONS, OR MATERIALS. A STRUCTURE OF INDUSTRY WAS DEVELOPED AND REFINED TO CONTAIN 14 MAJOR CONCEPT AREAS INTENDED TO REPLACE INDUSTRIAL ARTS IN THE SECONDARY SCHOOLS. A FORMAT WAS DESIGNED FOR THE PREPARATION OF RESOURCE UNITS. DEVELOPMENT OF MATERIALS FOR THIS CONTINUING PROGRAM WAS BEGUN BY 10 TEACHERS WHO TOOK PART IN AN 8-WEEK SUMMER WORKSHOP CONDUCTED UNDER THIS STUDY. A FIELD TRIAL WAS INITIATED IN THE FALL 1964 WHEN THESE TEACHERS INTRODUCED COURSES IN AMERICAN INDUSTRY VARYING IN LENGTH FROM 6 TO 36 WEEKS AT GRADE LEVELS FROM 7 THROUGH 12. FUTURE DEMONSTRATION OF PROGRAM EFFECTIVENESS, DEVELOPMENT OF INSTRUCTIONAL MATERIALS, AND EXPERIMENTS ON TEACHER PREPARATION WERE PLANNED. (JM)

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DEVELOPMENT OF A CONCEPTUAL FRAMEWORK FOR THE TEACHING OF INDUSTRIAL ARTS

Cooperative Research Project No. S-068

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THE PROBLEM

What is the place of industrial arts in the educational programs of our technological society? Industrial arts traditionally has accepted as one of its major objectives, developing an understanding of industry. In actual practice, however, efforts have been limited to treatment of selected trades, occupations, and/or material areas. In addition, the primary emphasis, within these narrow categories, has been upon developing the ability to perform specific operations.

In recent years this narrow approach has come into increasing question by leaders in technical education and, indeed, by those of other disciplines as well. This searching examination of industrial arts has led to several isolated experimental programs which have tended to be atomistic in approach rather than being based upon a complete theoretical orientation to a broad study of industry.

It was felt that the problems of the future are inseparable from increasing industrialization and that all young people must adequately understand technology as an ever more potent force in the molding of our society. In order for young people to fully appreciate the impact of technology upon their daily lives industry itself must be studied and understood. This study must aim for comprehension of the broad scope of industry and not merely focus upon isolated trades, occupations, or materials.

For the purposes of this study, industry has been defined as " a complex of organizations that utilizes the basic resources of men, materials, machines, and money to produce goods or provide services to meet the needs of man."

The major problem involved in attempting to analyze our industrial complex for curriculum purposes lies in knowing how to identify what is to be learned. Analysis procedures aimed at identifying the thousands of specific bits information could lead the curriculum planner back into the trap of structuring his offerings on the basis of isolated segments of the total complex. In attempting to develop broader understandings it seems evident that broad relationships should be stressed. A conceptual analysis holds much promise and provides the needed direction in our attempts to develop an adequate structure of our content area.

A conceptual approach to the identification of the structure of industry is predicated upon the premise that the multitude of specifics which make up the body of industrial knowledge can be studied and understood under a smaller number of organizing concepts.

For the purpose of this study a concept was defined as "a psychological construct resulting from a variety of experiences (detached from the many situations giving rise to it), fixed by a word or idea, and having functional value to the individual in his thinking and behavior."

The problem, restated, involved two aspects: (1) providing a reorientation for industrial arts organized about a comprehensive study of industry, and (2) identification of the major concepts of industry.

This project has attempted to develop a program intended to replace the typical industrial arts offerings in the secondary schools. Since it is viewed as a new area of study it will be referred to throughout this report as the study of American industry.

OBJECTIVES

The overriding general objective of the project was to provide a new orientation for industrial arts teachers in the secondary schools through the development of a conceptual framework identifying American industry as a curriculum area in our schools. The lack of logical consistency evidenced by the traditional industrial arts programs existing in the secondary schools made it clear that what was needed was not merely a new approach, or an addition to present industrial arts offerings, but rather a completely new program.

The specific objectives of this project in moving toward the attainment of the general goal, were seen as:

(1) To refine the rationale and development of a theoretical framework which uses basic concepts of industry for purposes of curriculum development.

(2) To complete an inventory of basic concepts which can provide an articulated curriculum for industrial arts in our secondary schools, and which could be tested in actual teaching situations in selected schools.

(3) To begin the development of subject matter content and learning activities based upon this new approach.

(4) To complete plans for implementation steps, including a summer workshop for experienced teachers (1964) and arrangements for experimental programs in selected schools.

REVIEW OF LITERATURE

The review of literature was undertaken with the aim in mind of identifying an acceptable definition of a concept and developing an understanding of the ways in which concepts are formed.

DEFINITION OF A CONCEPT

In the lite ature there seemed to be almost as many definitions of a concept as there ere writers on the subject. Concepts are inextricably bound up in the thinking behaviors of man and while a body of research on the matter is emerging, the term concept remains extremely difficult to define to complete satisfaction. In the attempt to evolve an acceptable definition of a concept for use as a tool in analyzing the conceptual structure of industry it appeared necessary to draw upon the contributions of a number of writers, each of whom provided an added dimension of understanding.

The difficult nature of concept definition was indicated by Brownell and Hendrickson (1950) who stated:

> A concept is far more than a "word," far more than an arbitrary association . . . A concept is an abstraction.
>
> As a matter of fact, concepts as abstractions may relate to nothing which is immediately and directly available to sense. (Brownell and Hendrickson, 1950, p. 106).

The problem is not a new one as recognized by Russell (1956).

> Aristotle and Plato were both concerned with the character of "universals," and their relation to "particulars." For Plato, the idea was the reality and the world; to be real, an idea must be univeral, necessary, and changeless. The discovery of such ideas (or concepts) should be the object of study. In contrast, Aristotle was much more concerned with sense date for their own sake and as the source of all cognition. He believed that thought was true, if incomplete, reproduction of reality--incomplete because the object as

> it exists in nature can never be directly known in human understanding. In Aristotle's philosophy, the essence of concrete reality exists, in thinking, in the form of an abstraction, or concept, as we use the term. (Russell, 1956, p. 119).

Although the task appeared difficult the value of a continuing search was affirmed by Phenix (1956).

> By a careful analysis of the structure of knowledge it is possible to discover certain key concepts distinguished by their power to epitomize important common features of a large number of more particular ideas. Such concepts are basic central ideas, an understanding of which opens the door to an effective grasp of an entire field of knowledge. (Phenix, 1956, p. 137).

One aspect of an acceptable definition emerged from a statement by McDonald (1959) who describes a concept as ". . . a classification or systematic organization of stimuli, characteristics, or events which have common characteristics." (McDonald, 1959, p. 134). The concept was seen as ". . . not the event itself, nor even the stimulus experience itself. . ." but as a classification system.

Although McDonald pointed to the classification characteristic of a concept, Russell (1956) identified another aspect in the interlocking and interactive nature of concepts themselves in his descriptive statement: "Concepts are not single stalks of wheat in separate rows, but a wheat field waving as one in the breeze." (Russell, 1956, p. 124).

A concept was seen by Keith (1907) as a functional process rooted in reality.

> Hence, a concept is a mental activity symbolizing the essential relations of a group of actual or possible experiences which are thought of originally in image terms.
>
> The concept is not cut off from concrete reality--it is simply the mind's way of "thinking the many into one," or, as philosophers say, "finding unity in variety."
>
> All concept forming is a synthesis; all definition is an analysis. (Keith, 1907, p. 128).

Keith's view was supported by Dewey (1933).

> Conceptions are the intellectual instrumentalities that are brought to bear upon the material of sense perception and of recollection in order to clarify the obscure to bring order into seeming conflict, and unity into the fragmentary. (Dewey, 1933, p. 179).

Carner and Sheldon (1954-55) summarizing their own reviews of the literature on the subject, stated that:

> Although the term may be defined in many ways there is general agreement that a "concept" is a construct which is the result of experience, may be fixed by a word or an idea, and has a functional value to the individual in his thinking or behavior. (Carner and Sheldon, 1954-55, p. 226).

Burton, Kimball, and Wing (1960) agreed in substance with Carner and Sheldon but added that "A concept is a suggested meaning which has been detached from the many specific situations giving rise to it. . . ." (Burton, et al. 1960, p. 154).

Consideration of the numerous aspects of a concept revealed in the literature led to the construction of the eclectic definition of a concept which served as a tool in the refinement of the conceptual structure of industry. This definition (as mentioned earlier), for the purposes of this study, describes a concept as a psychological construct resulting from a variety of experiences (detached from the many situations giving rise to it), fixed by a word or idea, and having functional value to the individual in his thinking and behavior.

CONCEPT FORMATION

As with the definition of a concept, there was a considerable amount of information available in the literature regarding the formation of a concept. While there existed considerable agreement upon certain aspects of concept formation, again, each writer added a dimension of meaning to what was known about this elusive subject.

In the following treatment of the review of literature on concept formation areas of general agreement are presented as working generalizations considered to be of paramount importance to the curriculum planner. Where appropriate, implications are drawn to the extent they add meaning to the generalization.

Generalization 1. Many of our most often used concepts are achieved incidentally, or accidentally, while in the pursuit of an interest, in solving a personal problem, or during the conscious and purposive effort to understand some segment of the environment. Burton Kimball, and Wing (1960), Russell (1956).

Implication: It must be recognized that those concepts used most frequently in our daily lives have developed because of a need or interest. The curriculum planner must endeavor to organize learning activities based upon an awareness of these needs.

Generalization 2. Concepts may be learned through formal (organized) as well as informal (accidental) experiences, although little is known about the best method of organizing formal experiences. Garrison and Gray (1955), McDonald (1959), Sutton (1963).

Implication: Recognition of the lack of an accepted methodology should not divert the educator from his aim of concept formation but suggests a variety of approaches should be used.

Generalization 3. The student brings with him an existing system of concepts which the school must recognize in its attempts to organize formal learning experiences. Sutton (1963), Thomson (1959).

Generalization 4. In learning a concept, the experiences required, the circumstances under which the concept may develop, and the level of understanding attained will vary for each individual. Lee and Lee (1960).

Implication: In accepting the fact that various levels of understanding of a given concept may exist, the educator may well find the teaching of a concept more appropriate to individual differences than if he were to demand equal levels of achievement in the mastery of a given body of content.

Generalization 5. Concepts are formed through a variety of experiences. Brownell and Hendrickson (1950), Landreth and Reed (1942), Lee and Lee (1960), Morse and Wingo (1962), Townsend and Burke (1962).

Implication: The educator must keep both the definition of a concept and this generalization constantly in mind, for concepts are not formed through the repeated exposure to identical experiences but rather through a variety of experiences, each of which will aid the learner in his development of a given concept.

Generalization 6. The formation of a concept is rooted in perception. Broudy (1962), Russell (1956).

Implication: The student who approaches problems conceptually is able to perceive the similarities and commonalities that exist in seemingly different events.

Generalization 7. To acquire a concept a person must abstract, or infer from the sensory data, those elements which add meaning to his understanding. McDonald (1959).

Implication: It is not enough for the learner to simply observe the event. He must interact with the information in his thinking or behavior.

Generalization 8. Greater clarity will result if but one attribute of the concept is studied at a time. McDonald (1959), Townsend and Burke (1962).

Implication: Activities designed to develop a given concept should each introduce a limited number of characteristics of the concept to facilitate comparisons by the learner with what he already knows.

Generalization 9. Continued positive reinforcement enhances concept learning although negative examples help sharpen concept delimitations. McDonald (1959).

Implication: Positive examples of attributes of a given concept should be the primary means of developing understandings since use situations will call for a grasp of the positive relationships the learner holds in his understanding of the concept.

Generalization 10. In the beginning stages of concept formation direct and personal experience leads to more rapid learning of the concept. Garrison and Gray (1953).

Generalization 11: Individuals of maturity and wide experience may not need direct personal experiences, but are capable of developing an understanding of a concept through vivid vicarious experiences. Burton, et al. (1960), Kolesnik (1963).

Generalization 12. New concepts are formed when a person finds his present system of concepts are inadequate in a new situation, when he encounters different concepts, and when someone challenges his concepts. Burton, et al. (1960).

Implication: The curriculum planner should structure activities which call upon the learner to re-evaluate his system of concepts.

Generalization 13. An understanding of a concept is clarified and broadened through analyis, reflection, generalization, and discrimination. Burton, et al. (1960) Morse and Wingo (1962).

Generalization 14. Repetition of the opportunity to use a concept enhances learning and broadens the understanding of the concept. McDonald (1959).

Implication: A planned sequence of activities introducing new situations should be provided to insure the learner will have the opportunity to re-examine his concepts in new contexts at different stages in his developing maturity.

Generalization 15. Concepts have dimensions and exist at varying levels of complexity, therefore formation of a concept cannot be regarded as being final or fixed. Discrimination and generalization go on continuously. Burton, et al. (1960), Brownell and Hendrickson (1950), Kolesnik (1963), Serra (1952).

Generalization 16. Concepts are not achieved quickly but rather through a slow developmental process. Bradfield and Moredock (1957), Burton, et al. (1960), Brownell and Hendrickson (1950), Lee and Lee (1958) (1960), McDonald (1959), Morse and Wingo (1962), Stratemeyer, et al. (1947).

Generalization 17. Concepts are expressed in words or other symbols although it must not be assumed that the word is the concept, but rather, merely an expression of the concept. Kolesnik (1963), McDonald (1959), Morse and Wingo (1962), Russell (1956), Sutton (1963).

Implication: Mere verbalization should not be accepted as evidence of understanding of a given concept. The test of understanding lies in the ability to apply that concept to different use situations.

Generalization 18. It is possible for a given word or symbol to represent more than one concept among different individuals. Serra (1952).

Implication: Care must be exercised in choosing words or other symbols to represent a given concept. Communication problems may arise through dependence upon isolated word symbols.

Townsend and Burke (1962) recognizing many of the generalizations drawn above offer the following suggestion to curriculum planners:

> For building concepts, whether based on real or vicarious experiences, breadth of training in diverse meanings and the ability to concentrate on one aspect of the situation at a time are paramount. The well-developed use of concepts provides a wealth of vicarious experiences to enrich life and to give their user control over the self and the environment. (Townsend and Burke, 1962, p. 252).

PROCEDURE

In order to achieve the stated objectives of this research a project director was released from all teaching duties to concentrate his efforts on planning and carrying on the project. With the aid of other staff members, student assistants, and clerical help, a review of the literature on conceptual learning was undertaken. Based upon this review, a statement of rationale was developed. (See Appendix A).

A preliminary structure of industry evolved through a review of literature concerning industry, discussion with industrial education staff members organized into a seminar for this purpose, consulting with representatives from other disciplines, and consulting with industrialists. (See Appendix B).

The preliminary structure was reworked many times in the light of further study. The revised structure (See Appendix C) represents considerable refinement showing fourteen major concept areas as: energy, communication, transportation, public interest, financing, physical facilities, research and development, purchasing, industrial relations, marketing, management, production, materials, and processes. Each of the concepts represented by one of these fourteen terms, can be reduced to many minor concepts. Many of these minor concepts have been identified, but it is recognized that this is a task which demands continued effort.

A list of minor concepts based upon the developing structure, and identified concurrently with this development, is presented in Appendix D. The reader will note some apparent discrepancies between the categorization of these minor concepts and the preliminary structure shown in Appendix B. The inconsistencies revealed during the attempt to identify minor concepts was one of several factors leading to the evolution of the revised structure presented in Appendix C.

The minor concepts are now in the process of being correlated with the revised structural framework. While curriculum construction is accepted as a continuous process it was felt that the new activities constantly being introduced into industry will involve combinations of concepts which can be identified. At the time of this report considerable confidence was held toward the validity of the major concepts composing the revised structure. It has already been admitted that less confidence can be placed in the completeness of the minor concepts identified.

As the review of literature was undertaken, plans were made for the implementation of a field trial of programs based upon the conceptual study of American industry. Ten teachers in eight secondary schools in Wisconsin and Minnesota were identified to take part in the development of materials and the conduct of the field study. Superintendents were contacted concerning their willingness to have their schools participate in the field study, and those teachers who had been recommended and expressed willingness to attempt to introduce a new program, were brought to the campus of Stout State University during the summer of 1964. For eight weeks, the ten teachers concentrated efforts at becoming familiar with new content, identifying additional industrial concepts and developing resource materials.

At the beginning of the school term, in the fall of 1964, the ten teachers who took part in the summer workshop introduced courses in American industry varying in length from six to 36 weeks, at grade levels from seven through twelve. This field test was looked upon as a developmental year in which materials and ideas were to be tried for the purpose of identifying the problems and questions involved in attempting to teach American industry under many varied conditions. This should provide needed direction for the refinement of the approach before presenting it on a demonstration basis.

A format was designed for the preparation of resource units and will serve as the basis for development of revised teaching materials growing out of the field experiences. The format and a sample resource unit may be seen in Appendices E and F.

Supervision of the field work was accomplished by monthly visitations by the project staff and was supplemented by a monthly workshop on the college campus. The expenses involved in the summer workshop and the field trial have been supported by funds from other sources.

An important part of the entire project has been the participation of college staff members not directly involved in the project. This was accomplished by the formal organization of a continuing series of seminars established in the early stages of development. In order to learn first hand of the problems being encountered in the field, an open invitation was offered to each department to accompany project staff on field visitations. This has proved to be a stimulating experience for all who have taken part and has been exemplified by their willingness to serve as consultants to the project staff, as well as to the teachers in the field.

Staff involvement has been further extended through small group meetings, on a departmental basis, to discuss the implications of field developments. These meetings came about as a follow-up to a presentation made to the total faculty and reflect the interest which has since developed.

On numerous occasions the project staff has been asked to report on the progress of the project to interested professional education groups. Considerable interest has been evinced at these meetings indicating that the industrial arts field is seeking a new direction.

RESULTS AND IMPLICATIONS

As a result of the conduct of this project the following results were achieved:

1. A statement of rationale was refined to serve as a guide in the development of a program of American industry intended to replace industrial arts in the secondary schools.
2. The body of knowledge drawn from industry was found to have an identifiable structure of concepts which may be used as the basis for curricular planning.
3. Fourteen basic concepts were identified as composing the major structure of American industry. While this basic structure can be justified with some confidence, and curriculum approaches based upon it have been designed and implemented, additional work is necessary in detailing the minor concepts.
4. Initial resource materials developed as an outgrowth of this project were subjected to field test and will be revised in the light of this field experience.
5. Cooperation of eight school districts was obtained with ten teachers identified to take part in a summer workshop followed by a year's field test of materials and activities.

In consideration of the results of this project, far reaching implications for industrial arts education may well be envisioned. If the American industry program bears out its promise, the long felt need for direction could be satisfied.

Before this can occur the program of American industry must be demonstrated in many different situations under the supervision of a research staff. The preliminary planning has taken place and the field

test has been initiated. The actual demonstration as to the effectiveness of the program must be a next step in the experimentation. This demonstration would lead to the development of an articulated program in American industry and to the development of the necessary instructional materials. Along with this demonstration in the secondary schools there must also be parallel experimentation in preparing new teachers for the program. A formalized procedure for retraining industrial arts teachers must also be a part of this experimentation.

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*These references having the asterisk were used for the preparation of this report.

Appendix A

A Statement of Rationale

A Conceptual Approach to the Study of American Industry

BY

Robert S. Swanson, Wesley L. Face, Eugene R. F. Flug

Introduction

During the school year 1962-63, a group of professors and administrators at Stout State University decided that it was time to do more than talk theoretically about changes which ought to be made in the traditional programs of industrial arts education. They agreed that there was need to experiment with a radical restructuring of the theoretical orientation of industrial arts, but that this must be accompanied by field testing as a necessary means of accepting, discarding, or revising new ideas.

Small group discussions soon grew into an organized faculty seminar. A faculty member was given released time to begin developing a procedure for the further study and implementation of a new program, called American Industry,[1] firmly based in a theory of education which was logical in structure, cognizant of current psychological findings, and guided by a consistent philosophy of education. American Industry, a curriculum area, is conceived as a discipline in that it has an identifiable structure.

A proposal was submitted to the U. S. Office of Education for financial support. The ensuing grant was used primarily to carry the program through the initial planning stages. Concurrently a plan of implementation was formulated to train ten selected industrial arts teachers to field test the program. A one year program for the implementation of the field study was approved by the Ford Foundation, resulting in an additional grant of monies.

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[1] Throughout this chapter American Industry will be used to refer to the title given to this curriculum area, and the term industry will refer to the institution which exists in American society.

DURING THE SUMMER OF 1964, AN EIGHT WEEK WORKSHOP WAS HELD WITH TEN TEACHERS REPRESENTING EIGHT SECONDARY SCHOOLS IN WISCONSIN AND MINNESOTA. AT THE TIME OF THIS WRITING, THE EXPERIMENT IS WELL UNDER WAY IN EIGHT SCHOOLS WITH OFFERINGS BY THESE TEN TEACHERS, VARYING IN LENGTH FROM SIX WEEKS TO A FULL YEAR AT GRADE LEVELS FROM SEVEN THROUGH TWELVE.

THE FIRST YEAR IS LOOKED UPON AS A DEVELOPMENTAL YEAR AND IT MUST BE REPORTED THAT WHILE THERE IS ENTHUSIASM AMONG THOSE FACULTY MEMBERS WHO HAVE BEEN MOST CLOSELY INVOLVED IN THE INITIAL STAGES OF THE PROJECT, THERE IS A MEASURE OF HONEST SKEPTICISM ON THE PART OF OTHERS. THIS IS SEEN AS A HEALTHY CHALLENGE WHICH WILL BEST BE ANSWERED BY THE RESULTS OF THE FIELD TESTS IN THE CLASSROOMS AND LABORATORIES.

THE EXPERIMENTAL NATURE OF THE PROGRAM OF IMPLEMENTATION SHOULD BE KEPT IN MIND AS THE READER REVIEWS THE FOLLOWING STATEMENTS OF RATIONALE.

OBJECTIVES OF THE STUDY OF AMERICAN INDUSTRY

THE OBJECTIVES SEEN FOR THE PROGRAM IN AMERICAN INDUSTRY HAVE GROWN FROM A CAREFUL STUDY OF EXISTING STATEMENTS OF THE PURPOSES OF AMERICAN SECONDARY SCHOOLS.

AN EARLY STATEMENT OF OBJECTIVES BY THE COMMISSION ON THE REORGANIZATION OF SECONDARY EDUCATION PROPOSED A SET OF SEVEN CARDINAL PRINCIPLES INCLUDING: HEALTH; COMMAND OF FUNDAMENTAL PROCESSES; WORTHY HOME MEMBERSHIP; VOCATIONAL COMPETENCE; EFFECTIVE CITIZENSHIP; WORTHY USE OF LEISURE; AND ETHICAL CHARACTER. IN 1938, THESE SEVEN CARDINAL PRINCIPLES WERE REDUCED BY THE EDUCATIONAL POLICIES COMMISSION TO INCLUDE: SELF REALIZATION, HUMAN RELATIONSHIP; ECONOMIC EFFICIENCY, AND CIVIC RESPONSIBILITY.

ACCEPTANCE OF THESE BROAD GOALS, DIPPING INTO EVERY FACET OF HUMAN LIFE, HAD LED THE SCHOOLS TO ASSUME MANY RESPONSIBILITIES WHICH WERE FORMERLY

CONSIDERED THE DOMAIN OF OTHER INSTITUTIONS IN OUR SOCIETY. WHILE IT WAS RECOGNIZED THAT THE SCHOOLS MUST CONSIDER ALL THESE FACTORS, THERE HAD BEEN A GROWING CONCERN THAT THE PRIMARY MISSION OF THE SCHOOLS HAD BECOME OBSCURED. AS A RESULT OF THIS CONCERN, THE EDUCATIONAL POLICIES COMMISSION, IN 1961, ISOLATED THE CENTRAL PURPOSE OF EDUCATION AS THE DEVELOPMENT OF THE RATIONAL POWERS OF MAN.[2] THE COMMISSION CLEARLY STATED THAT THIS WAS NOT NECESSARILY A UNIQUE CONTRISUTION OF EDUCATION, NOR WAS IT THE SOLE PURPOSE. IT REPRESENTED RATHER, AN ATTEMPT TO CONVEY THE IDEA THAT <u>THE RATIONAL POWERS ARE CENTRAL TO ALL OTHER QUALITIES OF THE HUMAN SPIRIT</u>. THIS POSITION IS CLARIFIED IN THE FOLLOWING STATEMENT MADE BY THE COMMISSION:

> A PERSON WITH DEVELOPED RATIONAL POWERS HAS THE MEANS TO BE AWARE OF ALL FACETS OF HIS EXISTENCE. IN THIS SENSE HE CAN LIVE TO THE FULLEST. HE CAN ESCAPE CAPTIVITY TO HIS EMOTIONS AND IRRATIONAL STATES. HE CAN ENRICH HIS EMOTIONAL LIFE AND DIRECT IT TOWARD EVER HIGHER STANDARDS OF TASTE AND ENJOYMENT. HE CAN ENJOY THE POLITICAL AND ECONOMIC FREEDOMS OF THE DEMOCRATIC SOCIETY. HE CAN FREE HIMSELF FROM THE BONDAGE OF IGNORANCE AND UNAWARENESS. HE CAN MAKE OF HIMSELF A FREE MAN.[3]

A COROLLARY OF THE CENTRAL PURPOSE OF DEVELOPING THE RATIONAL POWERS OF MAN LIES IN THE RESPONSIBILITY OF THE SCHOOLS TO ACQUIRE, PRESERVE, AND DISSEMINATE THOSE KNOWLEDGES WHICH HAVE BEEN DEVELOPED AND REFINED BY THE HUMAN INTELLECT, AND WHICH INTERACT WITH MAN'S ENVIRONMENT.

<u>THE BROAD OBJECTIVES</u> OF THE <u>AMERICAN INDUSTRY</u> PROGRAM WERE DERIVED DIRECTLY FROM AN ACCEPTANCE OF THIS CLARIFIED PURPOSE OF EDUCATION. THEY ARE:

1. TO DEVELOP AN UNDERSTANDING OF THOSE CONCEPTS WHICH DIRECTLY APPLY TO INDUSTRY.
2. TO DEVELOP THE ABILITY TO SOLVE PROBLEMS RELATED TO INDUSTRY.

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[2] EDUCATIONAL POLICIES COMMISSION. <u>THE CENTRAL PURPOSE OF AMERICAN EDUCATION</u>. (WASHINGTON, D.C.: NATIONAL EDUCATION ASSOCIATION, 1961), P. 4.

[3] IBID., P.9.

JUSTIFICATION FOR THE INCLUSION OF A STUDY OF INDUSTRY IN THE PUBLIC SCHOOLS WAS SEEN IN THE EMERGENCE OF TECHNOLOGY AS AN EVER MORE POTENT FORCE IN THE MOLDING OF SOCIETY. THE PROBLEMS OF THE FUTURE ARE INSEPARABLE FROM INCREASING INDUSTRIALIZATION AND YOUNG PEOPLE MUST BE LED TO AN ADEQUATE UNDERSTANDING OF THESE FORCES WHICH IMPINGE UPON THEIR DAILY LIVES.

THE STRUCTURE OF AMERICAN INDUSTRY

BRUNER, AS WELL AS BURTON, KIMBALL, AND WING, IMPLIES THAT ANY BODY OF KNOWLEDGE TO BE CONSIDERED AN INTELLECTUAL DISCIPLINE POSSESSES A FRAMEWORK OR STRUCTURE THAT CAN BE IDENTIFIED AND EXPRESSED IN TERMS OF THE CONCEPTS INVOLVED.[4]

NELSON, IN A REVIEW OF THE SUPPORTING LITERATURE, INDICATES THAT AN UNDERSTANDING OF THE STRUCTURE OF A SUBJECT IMPROVES THE QUALITY OF LEARNING BY:

1. PROVIDING SIMPLICITY,
2. MAKING DETAILS MEANINGFUL AND EASILY REMEMBERED,
3. REVEALING RELATIONSHIPS,
4. PROVIDING UNITY OF KNOWLEDGE,
5. ENABLING INDIVIDUALS TO ORGANIZE LEARNING FOR TRANSFER,
6. ENABLING STUDENTS TO EXPERIENCE DISCOVERY,
7. PROVIDING MEANINGFUL LEARNING TO STUDENTS OF ALL ABILITIES, AND
8. DEVELOPING IN STUDENTS THE ABILITY TO THINK.[5]

SOMMERS, IN COMMENTING ON THE LACK OF UNITY IN INDUSTRIAL ARTS, STATED, ". . . WE ARE FAILING TO FULFILL OUR MISSION FOR LACK OF A VIGOROUSLY DERIVED SET OF UNDERLYING PRINCIPLES THAT REALISTICALLY GIVES STRUCTURE TO OUR PRODUCT - OUR INDUSTRIAL ARTS OFFERINGS."[6]

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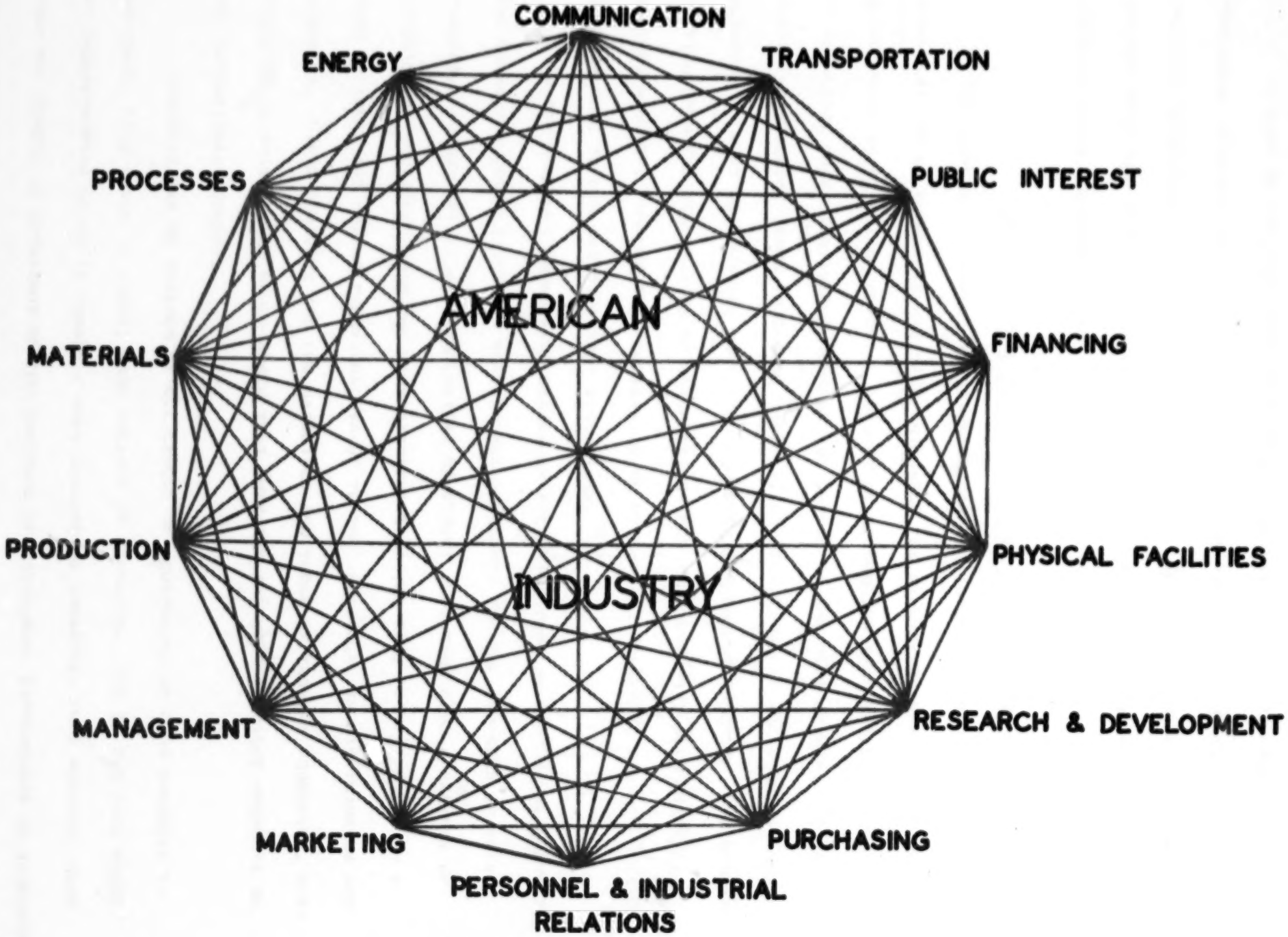
[4] JEROME BRUNER, "STRUCTURES IN LEARNING." NEA JOURNAL, MARCH 1963, P. 26 AND WILLIAM H. BURTON, R. B. KIMBALL, AND R. L. WING, EDUCATION FOR EFFECTIVE THINKING (NEW YORK: APPLETON-CENTURY CRAFTS, INC., 1960), P. 154.

[5] NANCY SMITH NELSON, THE CONCEPTUAL APPROACH TO TEACHING, (A REPORT SUBMITTED TO THE SCHOOL OF HOME ECONOMICS, UNIVERSITY OF WISCONSIN, 1964). P. 2.

[6] WESLEY S. SOMMERS, "TOWARD EXCELLENCE IN INDUSTRIAL ARTS," INDUSTRIAL ARTS AND VOCATIONAL EDUCATION. 51:20, NOVEMBER, 1962.

THE RECOGNITION OF THIS BASIC LACK OF COHERENT STRUCTURE, REPRESENTED IN THE CONTENT TAUGHT IN THE TYPICAL INDUSTRIAL ARTS SHOP, LED DIRECTLY TO WHAT WAS FELT TO BE ONE OF THE PRIMARY STRENGTHS OF THE PROGRAM OF AMERICAN INDUSTRY. WHEREAS, THE TYPICAL INDUSTRIAL ARTS OFFERINGS HAVE BEEN BASED UPON AN ANALYSIS OF SELECTED TRADES IN ORDER TO IDENTIFY SPECIFIC MANIPULATIVE OPERATIONS AND RELATED INFORMATION, THE APPROACH UPON WHICH THE PROGRAM OF AMERICAN INDUSTRY IS BASED AIMS AT IDENTIFYING BASIC CONCEPTS COMMON TO A VARIETY OF INDUSTRIES. FOR EXAMPLE, ALL FORMS OF FASTENING CAN BE CATEGORIZED UNDER THREE MAJOR CONCEPTS: FASTENING BY ADHESION, BY COHESION, OR BY MECHANICAL LINKAGE. IN THE PROGRAM OF AMERICAN INDUSTRY, A STUDENT WOULD BE CONCERNED WITH ATTEMPTING TO DEVELOP AN UNDERSTANDING OF THE BASIC ATTRIBUTES OF, SAY, FASTENING BY MECHANICAL LINKAGE, RATHER THAN LEARNING HOW TO FASTEN BY THE USE OF WOOD SCREWS. THE STUDENT POSSESSING THE KNOWLEDGE OF THE BASIC ATTRIBUTES OF FASTENING BY MECHANICAL LINKAGE STANDS IN A BETTER POSITION TO MAKE A REASONED CHOICE OF FASTENERS WHEN DEALING WITH A VARIETY OF MATERIALS OTHER THAN WOOD.

STRUCTURE, AS USED HERE, SIMPLY REFERS TO A UNIFIED, BASIC DESCRIPTION OF THE SEVERAL FACETS OF INDUSTRY AS FOUND IN CONTEMPORARY AMERICAN SOCIETY. INDUSTRY IS CONCEIVED IN THIS STRUCTURE AS CONSISTING OF SEVERAL MAJOR AREAS, EACH OF WHICH IS FURTHER SUBDIVIDED INTO STILL SMALLER UNITS. INDUSTRY, FOR THE PURPOSE OF THIS PROJECT, IS DEFINED AS A COMPLEX OF ORGANIZATIONS THAT UTILIZED THE BASIC RESOURCES OF MAN, MATERIALS, MACHINES, AND MONEY TO PRODUCE GOODS OR PROVIDE SERVICES TO MEET THE NEEDS OF MAN. THE FIGURE "STRUCTURE OF INDUSTRY SHOWING MAJOR CONCEPTS" GRAPHICALLY PRESENTS THIS PROCESS OF ANALYSIS. THE BREAKDOWN DOES NOT STOP HERE, AS IT CONTINUES TO STILL SMALLER UNITS, UNTIL THE ULTIMATE GOAL IS REACHED--A MINOR CONCEPT. IT SHOULD BE EMPHASIZED THAT EACH LEVEL, DIVISION, AND SUBDIVISION, REPRESENTS A CONCEPT--SOMETHING TO BE STUDIED FOR UNDERSTANDINGS.



THE STRUCTURE of INDUSTRY

IT MUST BE STRESSED THAT THIS STRUCTURE, UNLIKE THOSE OF MANY OTHER PROPOSALS, ATTEMPTS TO CATEGORIZE UNDERSTANDINGS RATHER THAN CATEGORIZING SPECIFIC INDUSTRIES, MATERIALS, OR OCCUPATIONS. THUS, UNDERSTANDINGS OF CONCEPTS DERIVED FROM THIS STRUCTURE WOULD BE UNIVERSALLY APPLICABLE IN ANY SPECIFIC INDUSTRY WHICH ENCOMPASSES IT.

THE CONCEPTUAL APPROACH TO AMERICAN INDUSTRY

THE INCREASING COMPLEXITY OF THIS TECHNOLOGICAL AGE, LEADING TO MASSIVE ACCUMULATIONS OF KNOWLEDGE HAS MADE UNTENABLE THE ATOMISTIC APPROACH TO THE DEVELOPMENT OF TEACHING CONTENT. IT MUST BE RECOGNIZED THAT THE DYNAMIC NATURE OF KNOWLEDGE MAKES CONTINUOUS DEMANDS FOR CHANGE ON THE PART OF MAN. WHILE SPECIFIC KNOWLEDGE TENDS TO CHANGE RAPIDLY, BROADER CONCEPTS ARE MORE STABLE, ALTHOUGH IT MUST BE ADMITTED THAT EVEN CONCEPTS MAY CHANGE IN TIME. THE CONCENTRATION UPON THE ACQUISITION OF CONCEPTS, RATHER THAN EMPHASIS ON SPECIFICS, SHOULD, HOWEVER, ENHANCE THE POSSIBILITY OF RETENTION, TRANSFER, AND APPLICATION OF KNOWLEDGE TO NEW AND DIFFERENT SITUATIONS.

AFTER A RATHER EXHAUSTIVE REVIEW OF THE LITERATURE ON CONCEPTUAL LEARNING, THE FOLLOWING DEFINITION OF A CONCEPT WAS DEVELOPED FOR THE PURPOSES OF THIS PROJECT. A CONCEPT IS A PSYCHOLOGICAL CONSTRUCT RESULTING FROM A VARIETY OF EXPERIENCES (DETACHED FROM THE MANY SITUATIONS GIVING RISE TO IT), FIXED BY A WORD OR IDEA, AND HAVING FUNCTIONAL VALUE TO THE INDIVIDUAL IN HIS THINKING AND BEHAVIOR. SINCE CONCEPTS ARE THE MATERIALS AND TOOLS OF THOUGHT PROCESSES, MOST SCHOLARS IN THIS FIELD, WOULD AGREE THAT THEY ARE THE MOST PRECIOUS PRODUCTS OF THE EDUCATIONAL PROCESS.

CONCEPTS MAY BE GRASPED AT ALL LEVELS OF UNDERSTANDING FROM CONCRETE TO ABSTRACT; FROM VAGUE TO CLEAR; FROM INEXACT TO DEFINITE. DUE TO THE WIDE RANGE OF UNDERSTANDING WHICH IS POSSIBLE WHEN DEVELOPING CONCEPTS, THIS PROGRAM, MORE THAN ANY OTHER, IS COGNIZANT OF THE VARIANCE OF INDIVIDUAL DIFFERENCES IN STUDENTS. ONE STUDENT MAY HAVE A VERY LOW LEVEL OF UNDERSTANDING OF A GIVEN CONCEPT AND ANOTHER A MUCH HIGHER LEVEL. THE IMPORTANT CONSIDERATION, HOWEVER, IS THAT THEY BOTH HAVE UNDERSTANDING.

McDONALD SPEAKS OF TWO TYPES OF CONCEPTS. INFORMAL CONCEPTS ARE SEEN AS THOSE WHICH MAN FORMS INDEPENDENTLY AND HAPHAZARDLY AS HE INTERACTS WITH HIS ENVIRONMENT. FORMAL CONCEPTS ARE IDENTIFIED AS THOSE WHICH THE SCHOOL SYSTEMATICALLY ATTEMPTS TO DEVELOP.[7] THE TASK AHEAD LIES IN IDENTIFYING THE FORMAL CONCEPTS WHICH WILL COMPLETE THE STRUCTURE OF INDUSTRY SHOWN IN THE FIGURE. THERE ARE SEVERAL METHODS USED IN THE FORMATION OF CONCEPTS, ONE OF THESE BEING PRESENTED IN THE EXERCISE INCLUDED HERE.

CONCEPT FORMATION

IN ORDER TO UNDERSTAND MORE CLEARLY THE NATURE OF A CONCEPT, ONE MUST LOOK AT THE WAY IN WHICH CONCEPTS ARE FORMED. THE ACCOMPANYING EXERCISE ON FORMING A CONCEPT OF ADHESION SHOULD LEAD ONE TO A BETTER UNDERSTANDING OF A CONCEPT. (IT IS SUGGESTED THAT THE READER ACTUALLY COMPLETE THE EXERCISE, THEREBY ENABLING HIM TO BETTER APPRECIATE HOW A CONCEPT IS FORMED.)

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[7] FREDERICK J. McDONALD. EDUCATIONAL PSYCHOLOGY. (SAN FRANCISCO: WADSWORTH PUBLISHING CO., INC. 1959). P. 133.

AN EXERCISE IN CONCEPT FORMATION

DIRECTIONS: IN THIS TASK YOU WILL FORM THE CONCEPT OF ADHESION THROUGH SUCCESSIVE TRIALS. DURING EACH TRIAL, PLACE A RULER OR PIECE OF PAPER ALONG THE DOTTED LINE BELOW THE TRIAL. AFTER YOU HAVE MADE YOUR RESPONSE, MOVE THE RULER DOWN TO THE NEXT TRIAL.

IN EACH TRIAL YOU WILL LOOK AT THE STATEMENT AND TRY TO DETERMINE WHETHER IT IS AN APPLICATION OF FASTENING BY ADHESION OR NOT. AFTER A FEW TRIALS, YOU WILL BEGIN TO FORM HYPOTHESES ABOUT WHAT FASTENING WITH ADHESION REALLY IS. BY TESTING THESE THROUGH SUCCEEDING TRIALS, YOU WILL GRADUALLY DISCOVER WHICH PROPERTIES OR ATTRIBUTES DESCRIBE THE CONCEPT UNDER STUDY. IN THE END, YOU SHOULD HAVE AN IMPROVED CONCEPT OF FASTENING BY ADHESION.

TRIAL 1.

A. GLUING TWO BOARDS TOGETHER IS ADHESION.

B. IS NAILING OF TWO BOARDS TOGETHER FASTENING BY ADHESION?
YES___ NO___

TRIAL 2.

A. TRIAL 1B IS NOT FASTENING BY ADHESION.

B. IS CEMENTING OF LEATHER FASTENING BY ADHESION?
YES___ NO___

TRIAL 3.

A. TRIAL 2B IS FASTENING BY ADHESION.

B. IS BOLTING METAL TOGETHER FASTENING BY ADHESION?
YES___ NO___

TRIAL 4.

A. TRIAL 3B IS NOT FASTENING BY ADHESION.

B. IS RIVETING METAL TOGETHER FASTENING BY ADHESION?
YES___ NO___

TRIAL 5.

A. TRIAL 4B IS NOT FASTENING BY ADHESION.

B. IS PASTING PAPER TOGETHER FASTENING BY ADHESION?
YES___ NO___

TRIAL 6.

A. TRIAL 5B IS FASTENING BY ADHESION.

B. IS HOLDING TWO PIECES OF WOOD TOGETHER WITH SCREWS FASTENING BY ADHESION?
YES___ NO___

TRIAL 7.

A. TRIAL 6B IS NOT FASTENING BY ADHESION.

B. IS GLUING WOOD TOGETHER WITH ANIMAL HIDE GLUE FASTENING BY ADHESION?
YES___ NO___

TRIAL 8.

A. TRIAL 7B IS FASTENING BY ADHESION.

B. IS WELDING OF METAL FASTENING BY ADHESION?
YES___ NO___

TRIAL 9.

A. TRIAL 8B IS NOT FASTENING BY ADHESION.

B. IS SEWING OF TEXTILES FASTENING BY ADHESION?
YES___ NO___

TRIAL 10.

A. TRIAL 9B IS NOT FASTENING BY ADHESION.

B. IS CEMENTING TOGETHER OF TEXTILES FASTENING BY ADHESION?
YES___ NO___

TRIAL 11.

A. TRIAL 10B IS FASTENING BY ADHESION.

B. IS THERMOWELDING OF PLASTIC FASTENING BY ADHESION?
YES___ NO___

TRIAL 12.

A. TRIAL 11B IS NOT FASTENING BY ADHESION.

B. IS CONTACT CEMENTING OF FORMICA FASTENING BY ADHESION?
YES___ NO___

TRIAL 13.

A. TRIAL 12B IS FASTENING BY ADHESION.

B. IS SOLDERING OF METAL FASTENING BY ADHESION?
YES___ NO___

TRIAL 14.

A. TRIAL 13B IS FASTENING BY ADHESION.

B. IS GLUING WOOD TOGETHER WITH POLY-VINYL GLUE FASTENING BY ADHESION?
YES___ NO___

TRIAL 15.

A. TRIAL 14B IS FASTENING BY ADHESION.

B. IS BRAZING METAL FASTENING BY ADHESION?
YES___ NO___

TRIAL 16.

A. TRIAL 15B IS FASTENING BY ADHESION.

B. IS HOLDING TWO PIECES OF METAL TOGETHER WITH EPOXY RESIN FASTENING BY ADHESION?
YES___ NO___

TRIAL 17.

A. TRIAL 16B IS FASTENING BY ADHESION.

SUMMARY: IN YOUR OWN WORDS, DESCRIBE YOUR UNDERSTANDING OF THE CONCEPT OF FASTENING BY ADHESION.

THE CONCEPT OF ADHESION RESULTING FROM THIS EXERCISE WOULD PROBABLY BE SIMILAR TO THE FOLLOWING DEFINITION: ADHESION IS THE JOINING OF MATERIALS WITH AN UNLIKE SUBSTANCE IN A CONTINUOUS BOND INVOLVING MOLECULAR FORCE.

IT SHOULD BE NOTED THAT THE FORMATION OF A CONCEPT IS NOT DEVOID OF THE ACQUISITION AND THE CRITICAL EVALUATION OF SPECIFIC KNOWLEDGES. HOWEVER, THE RESULTING CONCEPT IS APPLICABLE TO MANY MORE SITUATIONS THAN THE SPECIFIC KNOWLEDGES GIVING RISE TO IT.

BEFORE ONE COULD PROGRESS IN THE DEVELOPMENT OF THIS CONCEPT IT IS NECESSARY TO HAVE A BASIC SYSTEM OF CONCEPTS, BUILT UPON PREVIOUS EXPERIENCE, TO CALL UPON TO HELP CATEGORIZE THE VARIOUS PROCESSES PRESENTED. SECONDLY, ONE HAS TO REACT TO THE MATERIAL PRESENTED; IT IS NECESSARY TO TAKE AN ACTIVE PART IN THE PROCESS. THIS POINT DESERVES FURTHER EMPHASIS. THE NEED FOR ACTIVE PARTICIPATION IN CONCEPT FORMATION IS REPEATEDLY STRESSED IN WRITINGS UPON THE SUBJECT. THE NATURE OF THE ACTIVITIES REQUIRED VARIES, DEPENDENT UPON THE LEARNER'S DEGREE OF SOPHISTICATION IN THE SUBJECT MATTER UNDER STUDY. IN THE EARLY STAGES OF THE ACQUISITION OF NEW CONCEPTS WHICH ARE QUITE DIFFERENT FROM THE EXPERIENTIAL BACKGROUND OF THE LEARNER, DIRECT INVOLVEMENT IS ESSENTIAL. FOR THIS REASON, THE INDUSTRIAL ARTS LABORATORY HAS BEEN CHOSEN AS THE PLACE IN WHICH TO INTRODUCE THE STUDY OF INDUSTRY.

IT SHOULD BE POINTED OUT THAT IT IS DOUBTFUL THAT EVERY READER WHO COMPLETED THE EXERCISE IN THE DEVELOPMENT OF THE CONCEPT OF ADHESION WILL HAVE A COMPLETE UNDERSTANDING OF THE CONCEPT. THE PERSON WHO HAD A STRONG BACKGROUND OF EXPERIENCE IN PHYSICS WOULD HAVE BEEN MOST LIKELY TO INCLUDE THE FACTOR OF MOLECULAR FORCE IN HIS DEFINITION, EVEN THOUGH THE EXERCISE DID NOT ELICIT THIS ATTRIBUTE OF THE CONCEPT OF ADHESION.

BASIC TO CONCEPT FORMATION IS THE ROLE PLAYED BY THE SENSES IN PERCEIVING OBJECTS, EVENTS, AND ATTRIBUTES. KEITH POINTED OUT THE ABSTRACT NATURE OF A CONCEPT DEVELOPED THROUGH PERCEPTION, BUT ROOTED IN REALITY: "THE CONCEPT IS NOT CUT OFF FROM CONCRETE REALITY, IT IS SIMPLY THE MIND'S WAY OF THINKING THE MANY INTO ONE OR AS PHILOSOPHERS SAY, FINDING UNITY IN VARIETY. (ITALICS NOT IN THE ORIGINAL)."[8]

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[8] JOHN A. H. KEITH. ELEMENTARY EDUCATION. (CHICAGO: SCOTT, FORESMAN AND CO. 1907), PP. 128-9.

SOME CONCEPTS--EXAMPLES

SEVERAL SELECTED EXAMPLES OF THE MANY CONCEPTS WHICH HAVE BEEN IDENTIFIED WITHIN THE TOTAL STRUCTURE OF AMERICAN INDUSTRY ARE AS FOLLOWS:

MANAGEMENT - THE TASK OF PLANNING, COORDINATING, MOTIVATING, AND CONTROLLING THE EFFORTS OF OTHERS TOWARD A SPECIFIC GOAL.

INDUSTRIAL RELATIONS - THE DETERMINATION AND CO-ORDINATION OF RELATIONS WITH EMPLOYEES AND THE PUBLIC TO PROMOTE THE BEST INTERESTS OF MAN AND THE ORGANIZATION.

PURCHASING - THE FUNCTION OF THE LIAISON AGENCY OPERATING BETWEEN THE PLANT ORGANIZATION AND OUTSIDE VENDORS ON ALL MATTERS OF PROCUREMENT.

RELIEF PRINTING - THE TRANSFERRING OF INK FROM A RAISED SURFACE DIRECTLY ONTO A SHEET OF MATERIAL RECEPTIVE TO INK, USUALLY PAPER OF SOME KIND.

OPEN-PIT MINING - A METHOD OF EXTRACTING ORE DEPOSITS LOCATED AT OR NEAR THE EARTH'S SURFACE.

HARDNESS - THE ABILITY OF A MATERIAL TO RESIST CRUSHING, DENTING OR PIERCING.

AIR TRAFFIC CONTROL - THE CONTROL OF AIRCRAFT WITH RESPECT TO SPEED, DIRECTION, ELEVATION, DEPARTURE, AND ARRIVAL.

DESTRUCTIVE TESTING - A CHECK ON MECHANICAL AND PHYSICAL PROPERTIES BY DESTROYING THE TEST SPECIMEN UNDER CONTROLLED CONDITIONS.

SHEARING - THE REMOVAL OF A CONTINUOUS CHIP THROUGH THE MOVEMENT OF A SHARPENED EDGE ALONG A STRAIGHT LINE PATH.

EXTRUDING - THE FORMING OF MATERIALS BY FORCING A MATERIAL THROUGH A DIE OF THE DESIRED SHAPE.

THESE SAMPLE CONCEPTS ARE REPRESENTATIVE OF THE GREAT VARIETY OF CONCEPTS WHICH ARE BEING IDENTIFIED IN THE ATTEMPTS TO REFINE THE STRUCTURE OF INDUSTRY. THE IMMENSITY OF THE TASK OF BRINGING UNITY OUT OF THE COMPLEX VARIETY OF KNOWLEDGE TO BE FOUND IN INDUSTRY REQUIRES CONTINUING EFFORTS IN THIS DIRECTION.

THE STUDY OF AMERICAN INDUSTRY AS A REPLACEMENT FOR THE TRADITIONAL INDUSTRIAL ARTS PROGRAM

THE EVOLVING PROGRAM OF AMERICAN INDUSTRY IS NOT ENVISIONED AS MERELY A NEW APPROACH, OR ADDITION, TO PRESENT INDUSTRIAL ARTS OFFERINGS, BUT RATHER AS DISPLACING THE TRADITIONAL PROGRAMS IN THE SECONDARY SCHOOLS. THE THINKING OF LEADERS IN THE FIELD AS EXPRESSED IN PROFESSIONAL PUBLICATIONS AND CONVENTION PROCEEDINGS, IN ADDITION TO PERSONAL OBSERVATIONS OF THE WRITERS OVER THE LAST TEN YEARS, HAVE BROUGHT A FULL REALIZATION OF THE NEED FOR A DRASTIC RE-ORIENTATION. THE TRADITIONAL INDUSTRIAL ARTS PROGRAMS IN EVIDENCE REFLECT A LACK OF LOGICAL CONSISTENCY GROWING OUT OF A VARIETY OF EDUCATIONAL PHILOSOPHIES.

A SUMMARY COMPARISON OF SOME OF THE ESSENTIAL CHARACTERISTICS OF AMERICAN INDUSTRY AND INDUSTRIAL ARTS MAY BE SEEN IN THE FOLLOWING:

TRADITIONAL INDUSTRIAL ARTS	AMERICAN INDUSTRY
1. COMPOSED OF A DETAILED STUDY OF KNOWLEDGES CONCERNED WITH PRODUCTION IN SPECIFIC INDUSTRIES FOR PRE-VOCATIONAL OR AVOCATIONAL PURPOSES.	COMPOSED OF A STUDY OF THE KNOWLEDGES CONTRIBUTING TO AN UNDERSTANDING OF THE TOTAL INSTITUTION OF INDUSTRY FOR GENERAL EDUCATIONAL PURPOSES.
2. THE SELECTION OF SPECIFIC INDUSTRIES FROM AMONG THE MANY POSSIBLE CHOICES HAS LED TO A MULTIPLICITY OF LABORATORY AND CURRICULUM PATTERNS, MAKING A COHERENT, UNIFIED, NATIONAL PROGRAM MOST DIFFICULT TO ACHIEVE.	THE IDENTIFICATION OF A STRUCTURE COMPOSED OF UNDERLYING CONCEPTS SHOULD MAKE POSSIBLE THE DEVELOPMENT OF A COHERENT, UNIFIED, NATIONAL CURRICULUM AND THE STANDARDIZATION OF LABORATORY FACILITIES.
3. PRE-SELECTED SKILLS, REPRESENTATIVE OF THE INDUSTRY UNDER STUDY, ARE IDENTIFIED AND SERVE AS THE ORIENTATION FOR THE COURSE OF STUDY.	CONCEPTS SERVE AS THE ORIENTATION FOR THE COURSE OF STUDY. SPECIFIC SKILLS ARE INTRODUCED AS THEY BECOME NECESSARY IN THE ACTIVITIES DESIGNED FOR THE DEVELOPMENT OF THE CONCEPT.
4. ATTEMPTS TO DUPLICATE THE TOOLS AND MACHINES OF INDUSTRY NECESSARY TO DEVELOP PRE-SELECTED SKILLS AND SPECIFIC KNOWLEDGES.	MAKES NO ATTEMPT TO DUPLICATE THE TOOLS AND MACHINES OF INDUSTRY, BUT UTILIZES WHAT FACILITIES ARE NEEDED TO DEVELOP UNDERSTANDINGS OF CONCEPTS.

PLANS FOR THE FURTHER DEVELOPMENT AND EVALUATION OF AMERICAN INDUSTRY

THE TEN TEACHERS INVOLVED IN THE PROGRAM ARE DEVELOPING TEACHING-LEARNING UNITS AND TESTING THEM IN THEIR CLASSROOMS. EACH SCHOOL IS VISITED BY THE PROJECT DIRECTORS AT LEAST ONCE EACH MONTH, AFTER WHICH ALL TEACHERS ARE CALLED BACK TO THE UNIVERSITY FOR A ONE DAY SEMINAR, EXCHANGING IDEAS AND DISCUSSING PROBLEMS.

THE FOLLOWING PROJECT GOALS HAVE BEEN ESTABLISHED:

1. IDENTIFY THE PROBLEMS INVOLVED IN IMPLEMENTING THE STUDY OF INDUSTRY USING THE CONCEPTUAL APPROACH.

2. REVISE THE CONTENT MATERIALS AND REFINE THE STRUCTURE OF INDUSTRY. SPECIALISTS IN OTHER DISCIPLINES, AS WELL AS FROM INDUSTRY, WILL BE CONSULTED REGARDING THOSE POINTS AT WHICH THE DEVELOPING BODY OF KNOWLEDGE OF INDUSTRY IMPINGES UPON THEIR AREAS OF SPECIALITY.

3. EXPAND THE RESOURCE FILE OF TEACHING MATERIALS THROUGH THE COOPERATION OF THE STOUT AUDIO-VISUAL CENTER AS WELL AS LEADING INDUSTRIES AND TRADE ASSOCIATIONS.

4. DEVELOP A SERIES OF STANDARDIZED TEST QUESTIONS FOR THE AMERICAN INDUSTRY PROGRAM

5. DEVELOP A SUGGESTED PROGRAM OF AMERICAN INDUSTRY FOR THE GENERAL SECONDARY SCHOOL. AN ATTEMPT WILL BE MADE TO DEVELOP THREE LEVELS,--BEGINNING, INTERMEDIATE, AND ADVANCED. THIS SHOULD COME AS AN OUTGROWTH OF THE FIELD EXPERIENCES.

6. THE PROJECT, IF SUCCESSFUL, WILL BE EXPANDED TO INCLUDE OTHER SECONDARY SCHOOLS.

7. DESIGN AN EXPERIMENTAL TEACHER EDUCATION PROGRAM TO ACCOMPANY THE BROADENED PROGRAM.

8. DEVELOP RECOMMENDED FACILITIES FOR AN AMERICAN INDUSTRY LABORATORY SPECIFICALLY FOR THE STUDY OF INDUSTRY.

9. DETERMINE AND DEVELOP THE KINDS OF ACTIVITIES MOST APPROPRIATE FOR TEACHING THE CONCEPTS OF INDUSTRY.

10. DETERMINE AN APPROPRIATE BALANCE BETWEEN CLASSROOM AND LABORATORY ACTIVITIES IN THE AMERICAN INDUSTRY PROGRAM.

11. DEVELOP MEANS OF DETERMINING THE EFFECTIVENESS OF THE PROGRAM OF AMERICAN INDUSTRY FOR VARIOUS STUDENT ABILITY LEVELS.

IT IS EXPECTED THAT DURING THE PILOT STUDY A GREAT NUMBER OF ADDITIONAL QUESTIONS WILL EMERGE. AS THESE QUESTIONS ARE IDENTIFIED THE GOALS OF THE CONTINUING IMPLEMENTATION WILL BE EXPANDED TO SEEK ANSWERS. IT MUST BE RE-EMPHASIZED THAT THE PROGRAM IS STILL IN THE DEVELOPMENTAL STAGES, HOWEVER, THE PROJECT STAFF IS CONFIDENT THAT THE BASIC RATIONALE PROVIDES THE NEEDED DIRECTION. WHETHER OR NOT IT MEETS FULL ACCEPTANCE, ALL THOSE INVOLVED IN THE PROJECT ARE PROCEEDING WITH THE EXHILARATING FEELING THAT THEY HAVE ACCEPTED THE CHALLENGE OF DEFINING THE DISCIPLINE REPRESENTED BY AMERICAN INDUSTRY.

Appendix B

Preliminary Structure of Industry

THE STRUCTURE OF INDUSTRY

(BODY OF KNOWLEDGE)

(CATEGORIES)

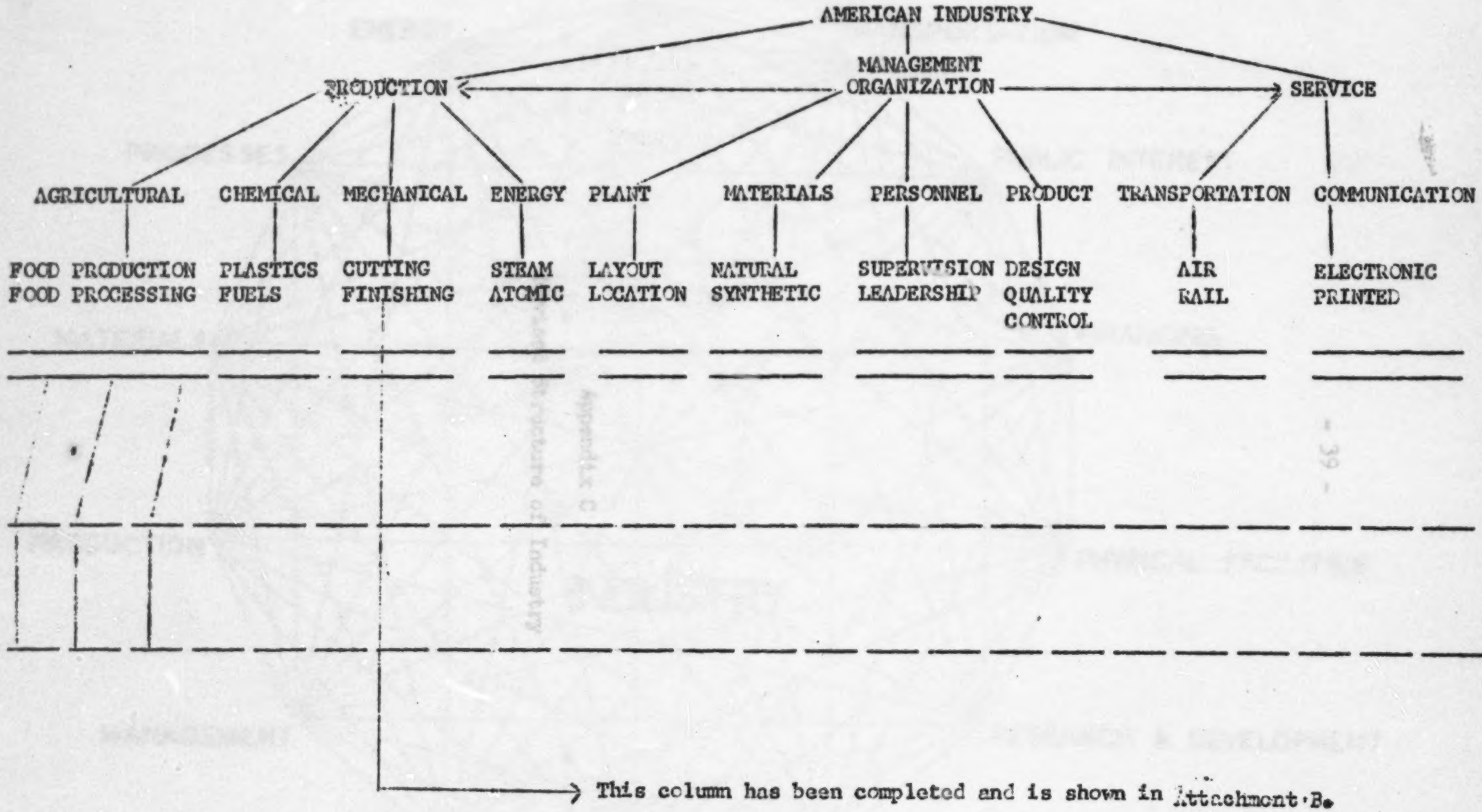
PERSONAL — MAINTENANCE — (FUNCTIONS)

FIRE PROTECTION — CIRCUIT ANALYSIS
LAW ENFORCEMENT — TROUBLE SHOOTING — (SUB-FUNCTIONS)

(INDUSTRIAL CONCEPTS)

(INDUSTRIAL ACTIVITIES)

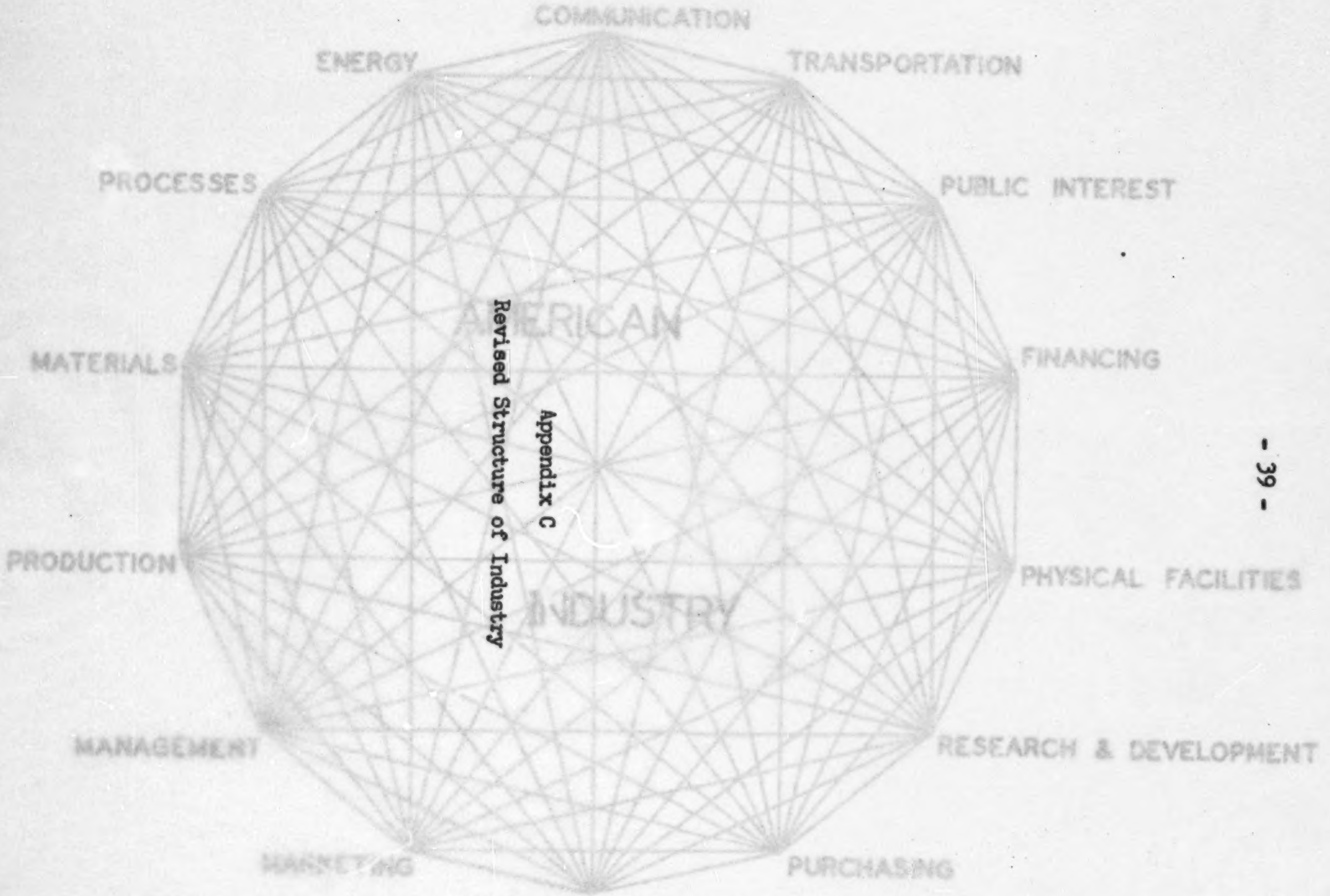
THE STRUCTURE OF INDUSTRY



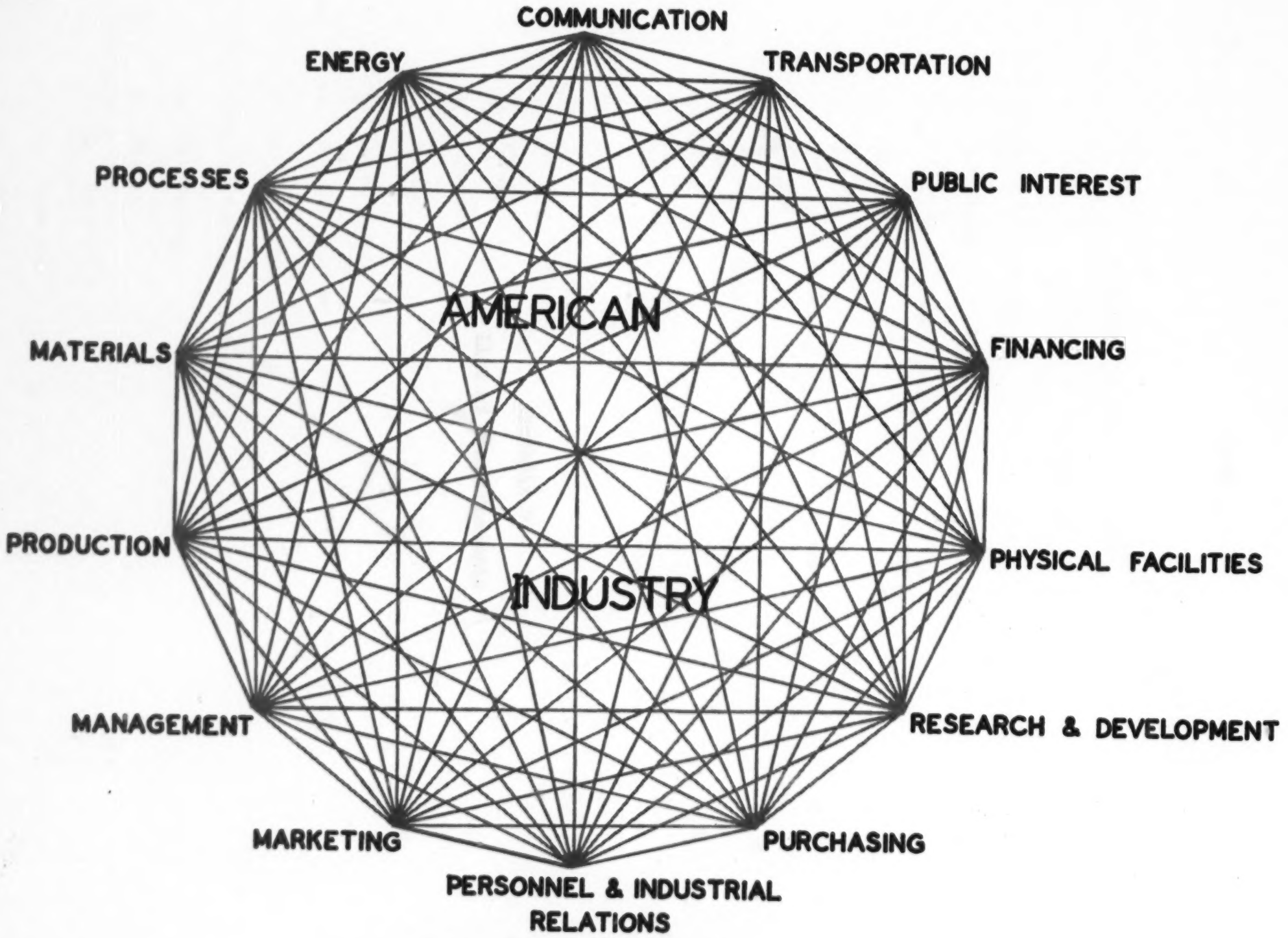
→ This column has been completed and is shown in Attachment B.

Appendix C

Revised Structure of Industry



THE STRUCTURE OF INDUSTRY



THE STRUCTURE OF INDUSTRY

Stout State University
July, 1964

EXAMPLES OF MINOR INDUSTRIAL CONCEPTS

MATERIALS

I. Material categories
   A. Adhesives
   B. Calcium accounting materials
   C. Ceramics
   D. Explosives
   E. Fibers
   F. Finishing materials
   G. Food
   H. Glass
   I. Metals
   J. Natural oils
   K. Petroleum
   L. Plastics
   M. Rubber
   N. Solid fuels
   O. Stone
   P. Wood products
II. Primary extraction methods
   A. Harvesting
   B. Mining
      1. Deep well
      2. Open pit
      3. Placer
      4. Underground

Appendix D

List of Minor Concepts

Stout State University
July, 1964

EXAMPLES OF MINOR INDUSTRIAL CONCEPTS

MATERIALS

I. Material categories
   - A. Adhesives
   - B. Calcium cementing materials
   - C. Ceramics
   - D. Explosives
   - E. Fibers
   - F. Finishing materials
   - G. Food
   - H. Glass
   - I. Metals
   - J. Natural oils
   - K. Petroleum
   - L. Plastics
   - M. Rubber
   - N. Solid fuels
   - O. Stone
   - P. Wood products

II. Primary extraction methods
   - A. Harvesting
   - B. Mining
     1. Deep well
     2. Open pit
     3. Placer
     4. Underground

III. Secondary extraction methods

A. Coagulation

B. Cooking, baking, and roasting

C. Curing

D. Dehydration

E. Distillation

F. Electrolysis

G. Fermentation

H. Milling

I. Preserving

J. Pressing

K. Reduction

L. Rendering

M. Replacement

N. Smelting

O. Solvent extraction

P. Vulcanization

(This list of secondary extraction methods is not complete, but represents those that were felt to be more important or difficult to understand)

IV. Terms (characteristics)

A. Brittleness

B. Conductivity

C. Corrosion Resistance

D. Creep

E. Ductility

F. Plasticity

G. Fusibility

H. Hardness

I. Insulate

J. Machinability

K. Malleability

L. Tenacity

M. Tensile strength

N. Toughness

O. Weldability

PROCESSES

I. Cutting

A. Abrasion

B. Electrical

C. Flame or heat

D. Drilling

E. Shearing

F. Planing

G. Rotary

H. Turning

I. Chemical

II. Fastening

A. Adhesion

B. Cohesion

C. Mechanical linkage

III. Finishing

A. Types

B. Purposes

C. Methods of application

IV. Forming

A. Bending

B. Blowing

C. Casting

D. Drawing

E. Extruding

F. Pressing

G. Forging

H. Rolling

V. Printing

A. Letter press

B. Lithography

C. Gravure

D. Silk screen

E. Electrostatic

VI. Inspection

A. Measurement

1. Lineal

2. Angular

3. Plane surface

B. Destructive testing

C. Non-destructive testing

VII. Physical property changes

A. Cold working

B. Hot working

C. Curing

ENERGY

I. Forms of energy

A. Mechanical

1. Potential

a. Elevated bodies

b. Deformed elastic bodies

2. Kinetic

a. Moving bodies

b. Turning bodies

B. Chemical

1. Foods

2. Fuels

C. Thermal

1. Solar

2. Terrestrial

D. Electrical

1. Electromagnetic

2. Electrostatic

3. Piezoelectric

E. Atomic

1. Fission

2. Fusion

3. Radioactivity

II. Harnessing energy

A. Chemical energy

1. Foods

2. Fuels

B. Solar energy

C. Electrical

1. Motors and generators

2. Electromagnetic waves

D. Atomic energy

1. The nuclear reactor

2. The thermonuclear reactor

E. Engines

1. Piston

2. Turbine

3. Jet

4. Rocket

III. Storage and transmission of energy

A. Mechanical storage

1. Gas receiver

2. Accumulator

3. Hydraulic

4. Elastic bodies

5. Flywheel

B. Mechanical transmission

1. Pumps

2. Pipes

3. Pneumatic

4. Hydraulic

5. Linkage

6. Air waves

7. Nozzles, diffusers

C. Heat transfer

1. Boiling

2. Superheating

3. Surface heat transfer

4. Mixed heat transfer

D. Electrical storage and transmission

1. Cells and batteries

2. Condenser

3. Transformer

4. Transmission systems

5. Electromagnetic waves

IV. Using energy

A. Performing mechanical work

B. Communication

C. Illumination

D. Air conditioning

1. Winter

2. Summer

MANAGEMENT - ORGANIZATION

I. Management

A. Function

B. Research

II. Organization

A. Structure

B. Management

C. Principles

D. Types of ownership

III. Functional areas

A. Marketing

1. Sales

2. Promotion and advertising

3. Servicing

4. Distribution

B. Product development

1. Research

2. Development

C. Manufacturing

1. Production

2. Plant services

3. Plant engineering

4. Types of production

D. Physical facilities

1. Location and building

2. Equipment

E. Industrial relations

1. Employee

2. Labor

3. Public

F. Purchasing

1. Procurement

2. Sub-contracting

G. Financing

1. Capital

2. Budget

3. Internal finance

TRANSPORTATION

I. Introduction to structure of transportation

- A. Historical developments
- B. Means of transportation
- C. Theory of movement

II. Point of origin and preparation

- A. Billing
- B. Packaging
- C. Loading
- D. Routing
- E. Weighing
- F. Marking
- G. Rates

III. Control

- A. Land transportation
- B. Air transportation
- C. Sea transportation

IV. Receiving

- A. Receiving
- B. Checking
- C. Handling
- D. Maintaining records

V. Destination

COMMUNICATION

I. Introduction to communication concept

- A. Source
- B. Encoder
- C. Transmitter

D. Channel

E. Receiver

F. Decoder

G. Destination

H. Interference

II. Direct means of communication

A. Verbal-sounds

B. Signals

III. Electronic

A. Wire communication

B. Wireless communication

IV. Graphic communication

A. Drawing

B. Printing

C. Photography

V. Three Dimensional Objects

Appendix E

Format for Preparing Instructional Resource Units

American Industry
Stout State University
December 17, 1964

FORMAT FOR PREPARING INSTRUCTIONAL
RESOURCE UNITS FOR AMERICAN INDUSTRY

CONCEPT TERM - (Attempt to reduce the concept to a single term).

CONCEPT DEFINITION - (This definition must be such that it will incorporate any sub-concepts and one from which all attributes or descriptive elements may be logically derived.) The definition of a concept as: a psychological construct resulting from a variety of experiences (detached from the many situations giving rise to it), fixed by a word or idea, and having functional value to the individual in his thinking and behavior, should be kept in mind at all times.

CONTENT OUTLINE - (This will be the reference use by the teacher.)

Show concept term, then outline content in sentence form. This outline should consist of the concept attributes which should be reduced to as few terms as possible, ideally a single term. Definition, specific facts, details, and techniques as illustrations should then be included as necessary to insure understanding.

BEHAVIORAL OBJECTIVES - (These objectives must be prepared in conjunction with expected behavioral changes in the student upon attainment of the objective. The objective statements should be quite specific. An excellent reference for the preparation of objectives has been prepared by: Robert F. Mager, "Preparing Objectives for Programmed Instruction". (Copies will be available for your use in Brekke Hall. The book is in programmed form and takes about a half hour to read.)

When writing objectives for each concept attempt to do so first in terms of the eighth grade student (this will be the beginning course attempting to develop a broad understanding of the total concept of American industry, emphasizing interrelationships of concepts throughout.)

Secondly try to state objectives for the learning of the same concept in terms of the tenth grade student who will be in a course wherein deeper understandings of the 14 concept areas will be developed. Then state objectives for the learning of some concept by the twelfth grade student who will be involved in researching a problem of considerable dimensions focussed more specifically upon a single concept area. This is seen as a time for specialization.

LEARNING ACTIVITIES - This represents the major creative effort involved in the preparation of these materials. An attempt should be made to really stretch your thinking in developing meaningful activities and put your imagination to work. As an aid to your thinking try to think of how you would get the students started toward the achievement of the objectives under consideration (introductory activities), how you would carry him along in his growing understanding (developmental activities), and how you would clinch the attainment of the objective (culminating activities). If you are not exhausted at this point give us some suggestions as to how you would evaluate the attainment of the objective. (NOTE: the better job you do in stating your objectives in behavioral terms the easier it will be to evaluate.)

TEACHING EXPEDIENTS - This should include a listing of any references used or suitable for use, suggested readings for the student, films, filmstrips, charts, or any other audio visual materials which would be appropriate. It is important that complete information be included as to source, title, cost.

Appendix F

Sample Resource Unit

American Industry
Stout State University
December 19, 1964

SAMPLE RESOURCE UNIT

Major Concept: Processes

Sub-Concept: Cutting

Unit-Concept: Abrasion - The removal of material through the cutting action of mineral particles.

I. Application

A. Abrasive cutting may be used to generate a size.

B. Abrasive cutting may be used to develop a specific surface finish, effect or condition.

C. Abrasive cutting may be used for the separation or cut off of materials.

D. Abrasive cutting may be used as a means of reducing a material to particle form.

II. Requirements

A. Hardness - Any material can be used as the mineral particle as long as it is harder than the material to be cut or it must be under high velocity before cutting action can result.

B. Movement - During the cutting process either the material to be cut or the mineral particle must be given movement or in some cases both may have movement.

C. Fracture - During the cutting action the mineral particle will fracture and produce a new series of cutting edges.

D. Controlled positioning and direction - The abrasive particle must be held in position for cutting or be forced against the material under pressure.

III. Types of abrasive particles

A. Natural - The mineral particles may be natural such as sandstone, garnet, emery, corundum, diamonds, etc.

IV. Form during usage

A. Loose form - The abrasive particles may be used in a loose form such as in the case of lapping, tumbling, and sand blasting.

1. Movement - The work is either moved through or over the particles, the particles are placed under pressure and directed against the material, or the particles are given movement and are held by adhering to a second body such as a buffing wheel.

2. Grit size - In all forms of abrasive cutting the size of the particle will effect the cutting action.

a. The larger the grit, the larger the cutting edges and the rougher the finish.

b. The smaller the grit, the smaller the cutting edges and thus the smoother the finish.

c. Grit size is determined by the size of the screen openings through which the grit may be sorted.

B. Solid form - The mineral particles may be held and used while in a cohesive mass such as grinding wheels, stones, and coated abrasives.

1. Bond - A bonding agent is the material used to hold the abrasive particles in the desired shape or form.

a. The bonding agent must allow for force involved at high speeds without breakdown of the bonding material.

b. The bonding agent must maintain coolness while cutting.

c. The bonding agent must be impervious to acid, water, and oil.

2. Grade - The grade of an abrasive tool is generally considered as the degree of strength with which the bonding material holds the particle in its shape or form.

a. Different strengths are required for different cutting situations.

b. In many cases it is desirable for the wheel to break down rather than wear down.

3. Structure - Structure is basically the voids or spaces which are developed between the particles once they have been bonded together into a cohesive mass.

a. Without voids continuous cutting could not take place.

b. The softer the material being cut the greater the need for openness in the structure.

c. With increased openness the final finish becomes rougher and with a more closed structure the resulting finish tends to be more smooth.

BEHAVIORAL OBJECTIVES

Student objectives for the unit dealing with the concept of cutting by abrasion at the first level in the curriculum - 8th grade.

1. The student will be able to specify and describe the type of basic abrasive cutting which would be most appropriate for eight specific cutting operations which are accomplished in industry.
2. The student will be able to determine those articles in his environment that have undergone abrasive cutting.

Student objectives for the unit dealing with the concept of cutting by abrasion at the second level in the curriculum - 10th grade.

1. After completing this sub unit of instruction, the student will be able to describe and identify six materials which are commonly used as abrasive parpticles.
2. Given a series of six abrasive tools, the student will be able to group them as to whether they are used in a loose or solid state.
3. The learner will be prepared to select and defend his selection of a bonding agent which is appropriate for the cutting of nonferrous metals, low carbon steels, and hardened steels.
4. After the completion of this sub unit the student will be able to contrast the situations in which a soft grade abrasive tool is used instead of a hard grade abrasive.
5. The student will be able to identify an open and closed structure in abrasive tools. He will also be prepared to name the type of structures that should be used for plastics, wood, nonferrous metals, and hardened steel.
6. The student will be able to determine the grit size of a selected amount of loose abrasive particles.

7. The student will be prepared to contrast a finish which has been produced by a large 30 grit particle from a finish produced by a 200 grit particle.
8. The student will be able to describe how abrasive particles fracture and produce new cutting edges.

Student objectives for the unit dealing with the concept of cutting by abrasion at the third level in the curriculum - 12th grade.

1. The student will, when given a piece of material of a given shape, size, and hardness, be able to design the abrasive tool necessary to complete a given operation.

TEACHING EXPEDIENTS

References

Each teacher should study these carefully:

1. Anstead, B. H. Manufacturing Processes. John Wiley and Sons, Inc., New York, 1963, 603-636.

2. The Carborundum Company. Carborundum bulletins. Niagara, New York, 1942. Read each of the twenty-five bulletins.

Visual Aids

The following films will be shown in conjunction with the laboratory activities.

1. "Old as the Hills" This film depicts man's discovery of abrasives and his universal need for them since the beginning of our civilization.

2. "Grits that Grind - A Story of Modern Abrasives" This film shows the manufacture of abrasive tools from the mines to the finished grinding wheel.

LEARNING ACTIVITIES

Introductory Activities

This unit of instruction may be introduced in a number of ways. There is no single best approach to the study of a given concept. One method which seems appropriate is through selected problem solving. The following problem would serve as an introduction to the knowledges concerned with this concept:

Introductory problem: The instructor will provide each student with a gallon container of abrasive particles and selected specimens of plastic, wood, non-ferrous metal, and hardened steel. He will then ask each student to devise a method by which the particles may be used to cut each of the selected materials. The student will be allowed to use any of the supplies which would commonly be available in the laboratory such as adhesives, paper, cloth, power sources, and the available tools and machines. After presentation of the problem the student will have a two-hour period to develop a solution to this problem. The method which is selected by the student need not be developed to a high level of sophistication but should illustrate the concept of cutting with mineral particles.

The student's choice of a solution to this problem will be tempered by his past experiences and his ability to visualize possible solutions.

Other possible introductory activities might be as follows:

1. Lecture demonstration - Display objects before abrasive cutting and after. Describe specific cutting operations used to achieve the results illustrated. Use blackboard illustrations, or charts.
2. Quiz - Matching - Display many examples of objects which have been cut by various specific cutting operations. Have students identify which operation was used.

3. Introductory Discussion - Start with rough object. State the problem - ex. finishing of roughcast object. Display abrasive materials in various states, i.e. abrasive wheel, belt, grit, buffing wheel, etc. Discuss limitations of each in turn.

Developmental Activities

In arriving at an acceptable solution to the introductory problem many sub-problems will develop. These may grow from the students' search for a solution or they may be presented by the teacher. The following problems and suggested activities are structured so that the student will develop an understanding of the subject matter concerned with cutting by abrasion:

1. What is the content of the abrasive particle? Is it man-made or natural? How is it processed from its raw state to a usable abrasive tool?

The solution to this problem may be developed through illustrated lectures or through a search of the literature by the student. The film "Grits that Grind--A Story of Modern Abrasives" will be shown at this time.

2. Before any material may be used to cut another material it must be harder than the material to be cut. It would be hoped that the student will develop this concept as he studies all forms of cutting. Is the abrasive particle harder than the selected materials which are to be cut?

The solution to this problem may be reached by having the student test the strength of the abrasive and compare it with the strength of each of the selected materials which are to be processed. This information may also be found through a search of the literature or given in an illustrated lecture. The actual testing of each of the materials involved, however, would seem the most appropriate since activity is of importance to concept formation.

3. In sub-problem No. 2 we have been concerned with not only the physical properties of the abrasive particle, but also certain properties of the materials which are to be cut. Does each selected material possess characteristics which must be considered when cutting by abrasion?

Most concepts do not exist in isolation. We cannot talk of cutting without considering the materials to be processed. We are in effect presenting concepts which deal with the physical properties of materials which are used in industry. The number of interrelationships which exist between concept is almost limitless. Thus the number of ways to approach the study of a specific concepts is equally broad. These interrelationships offer an excellent opportunity to reinforce knowledges learned in a separate unit.

4. How can the abrasive particle which feels very smooth actually cut any material?

This aspect of the problem may be best solved by having the student view the particles under magnification. This examination will prove to the student that the particles are not smooth, but rather possess sharp edges which are capable of cutting. This may also offer an excellent opportunity to ask the student to view the effects of cutting a hard material upon the individual cutting particles. The principle of fracture and the resulting new cutting edges can be viewed by studying under magnification an abrasive tool before and after it has been used on a hardened material.

5. Movement is necessary in all cutting operations. How can movement be introduced in this situation? Which shall move, the abrasive particles or the material to be processed?

This sub-problem may lead the student to the question of how the particles may be held in position for cutting. Most students being familiar with sand paper may propose that the particles be fastened to cloth or paper and then be given movement by hand or machine. The student may be asked to make a sample piece of abrasive cloth or paper. Perhaps this would be an excellent time to introduce or reinforce the concept of fastening by adhesion.

6. What type of an adhesive may be used to hold the particles to the paper or to hold them in a solid mass? How do various cutting operations affect the choice of bonding agents?

Many individual activities may grow from the search for a solution to these problems. The student may experiment with various types of bonding agents to determine the strength or grade of the resulting abrasive tool. The tool may be used to determine its ability to withstand breakdown, to maintain coolness, and to resist acid, water, and oil.

7. Why do grinding wheels cut faster than abrasive stones? Why do some abrasive tools become loaded with the materials being cut?

The solution to this problem will help the student develop an understanding of the structure of a solid abrasive tool. This may be illustrated by having the student try different abrasive tools on each of the selected materials. During such an experiment the student will note the effects of a closed structure versus an open structure and how some materials will load the tool if the structure is not appropriate.

8. Is the size of the abrasive particle an important consideration in determining its capacity to cut? Do various size grits cut at different rates? How is the grit size determined?

The student will experiment with different grit sizes and note the rate at which each will remove material from the selected samples. This will also indicate the resistance of each material to being cut by an abrasive tool. The problem of how grit is sized can be easily illustrated by having the student measure the size of the particles or through sorting by screening.

9. To this point the solution to our introductory problem has centered around the use of an abrasive in a solid mass or held to a paper or cloth backing. Some students may propose that the material should be moved over or through the loose abrasive particles.

At this time the instructor may present an illustrated lecture on sandblasting and tumbling, each a method by which the abrasive particles are used in a loose state. Tools to illustrate each of these processes can be simply constructed by the student. A simple sand blaster could be constructed by attaching a metal tube

to an air line with a small container to hold and feed the particles into the jet of air. Tumbling can be viewed by attaching a gallon can to a small electric motor. The can is loaded with the loose particles and the selected materials. As the can revolves the material is cut by abrasion.

10. At this stage the student will have some understanding of the principles involved in cutting by abrasion. Field trips could be made to selected industries to view the concept in action. If industries are not available there are many commercial films which illustrate these cutting operations. In either case the student should be asked to identify the basic considerations required in each of the observed operations which use the concept of cutting by abrasion.

11. Many questions could be asked by the student or presented by the teacher which would require the student to use his knowledge of other disciplines to gain a higher level of understanding of the concept of abrasion. What is the chemical composition of the mineral particle? What pressures or forces are present in cutting by this method? What is the best included angle for the abrasive particle for it to cut properly but still maintain the necessary strength? Geographically, where are natural abrasives located? Why are such minerals located in these areas? How are natural abrasives formed? Historically, when were abrasives first used? What need caused man to first use abrasives as a means of cutting? The film "Old as the Hills" will be shown at this time.

This list of questions could continue but perhaps this is adequate to illustrate that any concept has many levels of understanding. We can never assume that a complete understanding of all aspects of the concept is possible. Each student, however, can be expected to gain some understanding of the concept even if at a very low level of sophistication.

These questions should also demonstrate the relative ease with which we can coordinate other bodies of knowledge with the study of American Industry.

Culminating Activities

After completing the developmental activities the student will be asked to reconsider his original solution to the introductory problem. He will be given a two-hour period to either change or refine his original idea based upon the knowledges that he now has concerning cutting by abrasion.

Evaluating Activities

Part I

Directions: Read and answer each question carefully. When samples or specimens are mentioned, these will be given to you by your instructor.

1. For each of the following operations, name and describe a form of abrasive cutting that is the most appropriate for the specified operations:

   A. Blending: _____.

   B. Deburring: _____.

   C. Polishing: _____.

   D. Rough Cutting: _____.

   E. Descaling: _____.

   F. Burnishing: _____.

   G. Stress relief: _____.

   H. Deflashing: _____.

2. Here are six samples of abrasive particles. Using the microscope, determine the type of each of the abrasive specimens:

   Sample 1 _____

   Sample 2 _____

   Sample 3 _____

   Sample 4 _____

   Sample 5 _____

   Sample 6 _____.

3. Using the specimens in question 2, which would you use for cutting each of the following materials:

   Plastic _____

   Wood _____

   Nonferrous metals _____

   Hardened steel _____

4. Below you will find a list of abrasive particles and how they are being used. Indicate if the particles are a cohesive mass or in a loose state.

   A. The particles used in an oil stone. _____.

   B. The particles used in a wheelabrator. _____.

   C. The particles used in buffing _____.

   D. The particles used on abrasive cloth. _____.

   E. The particles used in sand blasting. _____.

   F. The particles used in tumbling. _____.

   G. The particles used in a vibrating chamber. _____.

5. For each of the following metals, list a bonding agent that would be appropriate. Explain why the bonding agent you have selected is the most appropriate.

   A. Nonferrous metals:

   B. Low carbon steel:

   C. Hardened steel:

6. If you are asked to grind a piece of tungsten steel, which would you use, a soft grade wheel or a hard grade wheel?

7. Here are four grinding wheels. Indicate if each has an open or closed structure.

   Wheel A _____

   Wheel B _____

Wheel C _____

Wheel D _____

Which of these would you use for grinding?

Plastic: Wheel _____

Nonferrous metals: Wheel _____

Wood: Wheel _____

Hardened steel: Wheel _____

8. Given a sample of abrasive particles, describe how you would determine the grit size.

9. Here are two specimens which have been ground by an abrasive belt. Which of these has been processed with a 30 grit belt? Which by using a 200 grit belt?

Specimen A _____

Specimen B _____

10. Describe how you would use loose abrasives to cut a selected piece of material.

11. Using the microscope, determine if this grinding wheel has been used. How do you know?

Part II

Directions: The following multiple choice questions are to be answered by underlining the answer which makes the statement complete and accurate.

1. Special grinding wheels for cutting off lengths of hardened steel are:

   a. Elastic wheels
   b. Vitrified wheels
   c. Silicate wheels
   d. Emery wheels

2. Clay, rubber, sodium silicate (water glass), shellac, and bakelite are all used in the manufacture of:

   a. Grinding wheels
   b. V belts
   c. Abrasive cloth

d. Abrasive paper

3. Grinding wheels seldom become "loaded" from grinding:

   a. Aluminum
   b. Brass
   c. Steel
   d. Bronze

4. The cloth-backed abrasives that are used to polish metal by hand may be used most efficiently in the:

   a. Presence of oil
   b. Dry state
   c. Presence of a soluble cutting oil
   d. Presence of powdered chalk

5. More than 75% of the grinding wheels used are bonded with:

   a. Vitrified bond
   b. Silicate bond
   c. Rubber bond
   d. Shellac bond

6. Each individual particle of grit on the face of a grinding wheel removes metal by:

   a. Rubbing
   b. Burning
   c. Scraping
   d. Cutting

7. The kinds of abrasives used in most wheels are silicon carbide and:

   a. Cemented carbides
   b. Ceramics
   c. Aluminum oxide
   d. Carbide

8. The grade of a grinding wheel depends upon the kind and quantity of:

   a. Grit that is used
   b. Natural mineral abrasive that is used
   c. Bond that is used
   d. Manufactured abrasive that is used

9. The coarser of the following grits is:

   a. 60 grit
   b. 80 grit
   c. 100 grit
   d. 150 grit

10. Natural abrasive crystals used in industry are:

   a. Crystolon, sandstone, aloxite
   b. Emery, carborundum, alundum

c. Sandstone, crocus, crystolon
d. Aloxite, carborundum, alundum

11. What is meant by "structure" of a grinding wheel?

a. Kind of abrasive
b. Size
c. Arrangement of abrasive particles
d. Amount of bond